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IoT Based Remote Low Voltage Power Circuit Breaker System in Flood Areas

Sistem Pemutus Aliran Listrik Tegangan Rendah Jarak Jauh Pada Wilayah Banjir Berbasis IoT

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Abstract

In some housing complexes with traditional electrical installation systems, electrical substations are often located in the middle of the housing complex or an area affected by flooding, causing the substation to be submerged and potentially endangering flood victims from being electrocuted. Based on these conditions, a remote voltage breaker system is needed to cut the electricity off automatically when the water level has passed a set point. This remote low-voltage electricity breaker system in flood areas is a tool for disconnecting the electrical system by detecting the water level. It can be monitored remotely based on IoT using an Android-based application. Using the HCSR04 Ultrasonic sensor to detect the water level in each container with a reading distance ranging from 2 cm to 450 cm, Ultrasonic sensor measurements will determine whether the detected water level is dangerous or not if the condition is dangerous, namely the detected water level is higher than the set point. Then, the MCCB will trip automatically. A microcontroller will process data and display the water level on the smartphone using the Blynk application. This tool uses a Node MCU-type microcontroller equipped with an ESP8266 WiFi module that functions as a regulator of the components used. The Blynk application will display water level monitoring data detected by the ultrasonic sensor in centimetre units. In the Blynk application, there is also a widget button that triggers the MCCB manually remotely. Several tests carried out on ultrasonic sensors produce the lowest error value of 1.49%, and the maximum trip time is 2.07 seconds.

Keywords: MCCB, ESP 8266, blynk, water level.

***SDGs*:**

Abstrak

Seringkali pada beberapa perumahan dengan sistem instalasi kelistrikan yang masih tradisional memiliki gardu listrik yang berada di tengah perumahan atau pada suatu daerah yang terkena banjir menyebabkan gardu terendam dan berpotensi membahayakan korban banjir tersengat aliran listrik. Berdasarkan kondisi itu maka diperlukan sistem pemutus tegangan jarak jauh dimana ketika ketinggian air sudah melewati titik yang ditetapkan maka listrik akan terputus secara otomatis. Sistem pemutus aliran listrik tegangan rendah jarak jauh pada wilayah banjir ini adalah alat untuk memutuskan sistem kelistrikan dengan cara mendeteksi ketinggian air yang bisa dimonitoring dari jarak jauh berbasiskan IoT dengan menggunakan aplikasi berbasis android. Menggunakan sensor Ultrasonik HCSR04 untuk mendeteksi ketinggian air yang berada pada setiap wadah dengan pembacaan jarak mulai dari 2 cm sampai 450 cm, pengukuran sensor Ultrasonik akan menentukan bahaya atau tidak ketinggian air yang terdeteksi, jika kondisi berbahaya yaitu ketinggian air yang tedeteksi lebih tinggi dari pada setpoint, maka MCCB akan Trip secaraotomatis. Mikrokontroller untuk memproses data, dan menampilkan ketinggian air pada aplikasi Blynk di smartphone. Alat ini menggunakan mikrokontroller jenis Node MCU yang dibekali dengan modul Wifi ESP8266 yang berfungsi sebagai pengatur dari komponen-komponen yan digunakan, aplikasi Blynk akan menampilkan data monitoring ketinggian air yang terdeteksi oleh sensor ultrasonic dalam satuan Centimeter, di dalam aplikasi Blynk juga terdapat Widget Button yang berfungsi untuk menTripkan MCCB secara manual dari jarak jauh. Dari beberapa test yang sudah dilakukan pada sensor ultrasonic menghasilkan nilai error terendah sebesar 1,49% dan lamanya waktu trip maksimal sebesar 2,07 detik.

Kata Kunci: MCCB, ESP 8266, blynk, ketinggian air.

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1. INTRODUCTION

Floods and excessive rainfall are unavoidable phenomena that can cause loss of people's lives and the ruination of infrastructure. However, the impact on human lives is relatively avoided by the presence of monitoring systems (Zahir *et al.*, 2019; Zakaria, 2021; Darwis *et al.*, 2023). The unpredictability of floods means that State Electricity Company (PLN) must always alert to ensure public safety. Previous research on the detection of floods with IoT has been conducted by Zidan and Windiastik, which has excellent result that IoT proved can help monitoring flood in areas (Windiastik, Ardhana and Triono, 2019; Zidan, 2022). Another way to prevent danger during floods is by Muhammad & Endah and Hirzan (Muhammad and Endah, 2020; Hirzan, 2022). Research by Shaputra et al., regarding an information system for monitoring water rise to overcome flood disasters by using arduino (Shaputra, Gunoto and Irsyam, 2019).Other research which also succeed is from Sadi, regarding the design of water level monitoring and control systems for Arduino-based water gates and SMS gateways (Sadi, 2018). Another danger from floods besides high levels is the danger from the electricity. Research has been done to avoid danger by monitoring low voltage system electrical circuit breakers based on the Internet of Things (IoT) in Flood Areas (Zidan, 2022), monitoring systems for floods and cutting the electricity conducted by Yusuf et al., with wireless sensor network installed in each and every house but it is relatively expensive and many of people in densely populated area can afford it (Yusuf, 2023).

One relatively cheaper and easier way is to cut off the Moulded Case Circuit Breaker (MCCB) from the stations in each area. MCCB is a system tool that protects cables against overloads and short connections, protects against insulation faults, and achieves a current flow peak without excessive heating. Electrical wires or circuit breakers are electrical switches that automatically work against overload and short circuits. This solution has also been implemented using a microcontroller and has yielded good results (Muhammad and Endah, 2020). Like a fuse only works once, a circuit breaker can be reset (manually or automatically) to return to its normal position. Circuit Breakers have various functions, from low voltage for household use to high voltage for great use. Circuit Breakers must detect fault conditions by opening the contacts and breaking the circuit. The circuit breaker contacts must be capable of withstand the load current without overheating and must also be able to withstand arcing caused by a circuit break. Circuit breakers are designed to protect the load from short circuit current and overload current and protect the insulator from damage. There are various types of circuit breakers, such as MCBB. Ways to Monitor the safety and the amount of current that occurs from a house by Controlling MCCB with SCADA to prevent wildfire has good result (Bunga, Pakiding and Silimang, 2015; Nurhakim, Suhanto and Sunaryo, 2019). Monitoring MCCB also made by using Iot with TCP/IP (Syafar, 2016). Monitoring power and current for home from MCCB by using microcontroller also conducted by Kastanja and Ishwar (Ishwar *et al.*, 2016; Kastanja, Laisina and Pelamonia, 2022). Centralized monitoring MCCB with microcontroller with IoT has excellent result from Widiantoko & Nugroho and Kulkarni et al. research (Widiantoko and Nugroho, 2019; Kulkarni *et al.*, 2022).

Regarding security, the MCCB can function as a disturbance safeguard. Short circuit currents and overload currents are usually installed on the outgoing generator with a low voltage system (< 1000 Volts). Based on previous research, no one came up with a solution for cutting off the electricity network or turning off the MCCB at the substation because when a large area is in high flood conditions, it is more practical and faster to cut off electricity from the station. Preventing dangerous damage by cutting off MCCB from far away has challenges, which is frequently the position of the substation is in the middle of the flood area, so it is hard for officers to do their job more by unpredicted behaviour of the flood. The solution offered by this research is to monitor substations in flood areas in real time. This solution has been conducted by Khan (Khan, 2022). The method that the author uses in this system is a Wi-Fi Controller with input from an ultrasonic sensor to send the message to the application Blynk to cut off the MCCB by detecting the water level in flood and sending the information to a website. This research uses 3 MCCBs as safety measures in different areas, three ultrasonic sensors monitoring the water level and cutting off MCCB by sending the information to the Blynk application on the Android system to minimize delay. If the condition is alert, the system will automatically turn off the electricity network by cutting off the flow of the MCCB. The flood position and MCCB on/off status can be monitored or controlled via an Android application.

From the above method, monitoring/monitoring substation conditions regarding water levels/floods and MCCB on/off conditions via the Android-based Blynk application. The Blynk application can provide information on water levels and MCCB on/off conditions. So, with a system for long-distance low-voltage electricity cutoffs in flood areas, officers anticipate electrical hazards due to flooding. Quick action can be taken to anticipate electricity cutoffs at PLN substations.

2. METHODOLOGY

The design of an electrical circuit breaker system monitoring system for long-distance low voltage in flood areas consists of hardware and software. Device design hardware includes HC-SR04 Ultrasonic Sensor, NodeMCU Microcontroller ESP8266, MCCB (Moulded Case Circuit Breaker), Pilot lamp, and Buzzer. Software design includes programming with a microcontroller NodeMCU ESP 8266 as processor, processor, and controller. The tool designed by the Blynk application monitors the water level and controller in deactivating the MCCB. This research is implemented using the following steps as seen on Figure 1 which are:

1) Design: The tool design stage begins with designing a general system diagram, describing its working principle, and designing a system modelling design. After obtaining appropriate results and data, the next stage is designing the hardware and software.
2) Realization After the hardware and software design stages, measurement and testing will be carried out.
3) Analysis and Evaluation Analysis is carried out after obtaining hardware and software testing results. Apart from that, the level of accuracy will also be analyzed.
4) Improvements and Completion conditions via the Android-based Blynk application. The Blynk application can provide information on water levels and MCCB on/off conditions. So, with a system for long-distance low-voltage electricity disconnect in flood areas, if there are several deficiencies in the tool, then the repair stage is carried out improvements so that the condition complies with the specifications.

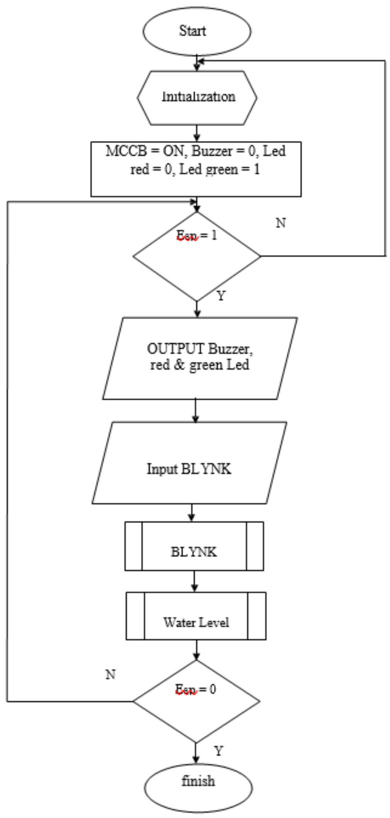

Figure 1. Flow diagram the stages of the research.

Design of the systems on Figure 2 consists of:

a. NodeMCU ESP 8266 Micro Controller
b. HC-SR04 Ultrasonic Sensor
c. Electrical Circuit Breaker
d. Blynk App

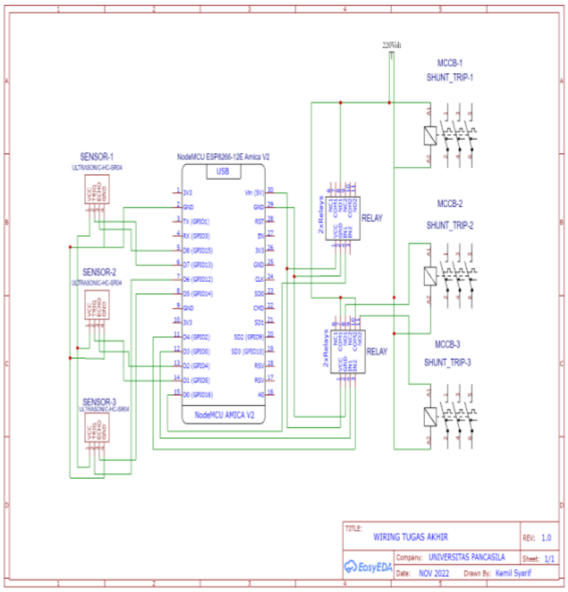

Figure 2. Design systems.

MCCB on Figure 3 is a low-voltage safety device that operates automatically against overloads and short circuits. This type of safety has a disconnection capability that can be adjusted as desired. MCCB functions as a low-voltage electrical network breaker. There are three MCCB in this systemswhich is analogous to area 1, areas 2, area 3 to secure the low-voltage electricity network in different regions.

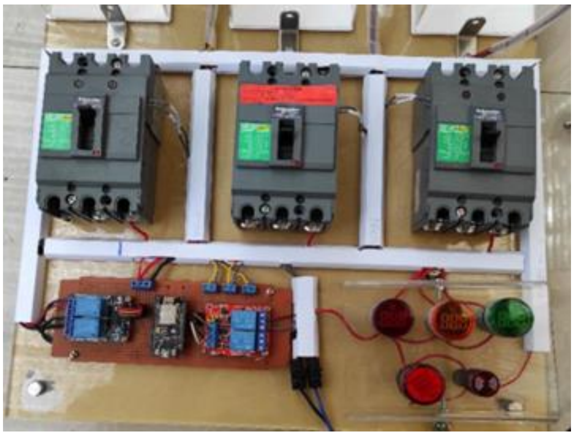

Figure 3. MCCB system.

On Figure 4 shows that the HC SR04 ultrasonic sensor is placed on a long container a 20 cm x 10 cm wide and 20 cm high, the HC SR04 ultrasonic sensor is used as input and attracts water level. In the delivers of this Long-Distance Low Voltage Electrical Circuit Breaker in Flood Areas, 3 HC SR04 ultrasonic sensors are used and are assumed to detect water levels in different areas.

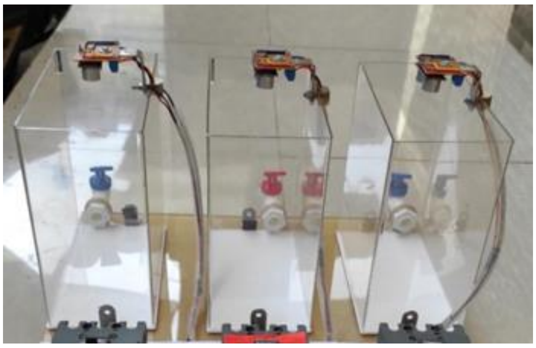

Figure 4. Systems prototype.

The NodeMCU ESP8266 as seen on Figure 5 is placed on the front of the acrylic board on the hollow PCB and assembled using connecting cables. The NodeMCU ESP8266 is used as a controller for the components used. The NodeMCU ESP8266 can be accessed using WiFi, so it can be accessed using the Blynk application.

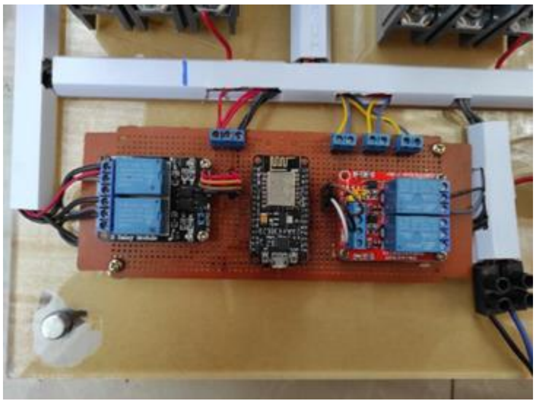

Figure 5. NodeMCU ESP8266 from systems.

3. RESULTS AND DISCUSSION

The purpose of this test is to find out the program's performance that has been created and how they are connected with ultrasonic sensor readings and then be able to trip the MCCB, monitoring and trip of MCCB over long distances using the Blynk application.

Testing water level readings by Ultrasonic sensors is done by comparing them to water level measurements using traditional validation methods. To know that the program that has been made works according to the desired performance, it is necessary to know the measurement error read by the Ultrasonic sensor. Ultrasonic sensor accuracy testing is carried out by comparing the traditional method with results from measuring instrument readings with the ultrasonic sensor readings and then measuring the error percentage on the first ultrasonic sensor, second ultrasonic sensor, and third ultrasonic sensor. Next, the ultrasonic sensor was tested on container 2 (region 2) similarly, as seen in the Table 1. Next, the ultrasonic sensor was tested on container 3 (region 3) similarly, as seen in Table 1. Referring to the water level reading data by the ultrasonic sensor shown in Table 1, there are differences in measurement data between the readings by the HC-SR04 ultrasonic sensor and measurements using a traditional way. Accuracy can be determined from this data by calculating the percentage error using the following formula:

$$error\ (\%) = \frac{sensor - traditional\ way}{traditional\ way}\ x\ 100\% \quad (1)$$

A recap of the error calculation of the difference between water level readings by the ultrasonic sensor and height measurements in the Traditional way, as seen in Table 2.

Table 1. Monitoring data for level sensor.

Testing Number	Monitoring Sensor Level (cm)	Monitoring Traditional Way (cm)	Deviation (cm)
1	15.2	15.18	0.06
2	15.1	15.2	0.1
3	15	15.02	0.02
4	15.05	15.06	0.01
5	15.21	15.16	-0.05
6	15.11	15.21	0.1
7	15.05	15.1	0.05
8	15.25	15.2	-0.05
9	15.03	15.24	0.21
10	15	15.04	0.04
Average error		**0.05**	**0.32**

Table 2. Monitoring data for ultrasonic sensors.

Testing Number	Error sensor ultrasonic 1 (%)	Error sensor ultrasonic 2 (%)	Error sensor ultrasonic 3 (%)
1	1,35	0.1	0,4
2	2,15	1,28	0,66
3	0,19	0,68	0,13
4	0,6	-0,5	0,07
5	0,78	0,79	-0,33
6	1,67	0,58	0,66
7	0,99	0,98	0,33
8	1,54	0,98	0,33
9	1,38	-0,59	1,38
10	-0,79	2,06	0,27
Average Error	**0,99**	**0,64**	**0,32**

Testing on the Blynk Application aims to discover what has been created and can send measurement data by an ultrasonic sensor to the Blynk application on a smartphone. By intermediary wifi without using cables (wireless), there is a distance limitation between the NodeMCU and wifi, which can cause interference in the form of delays in data transmission. This test was carried out to find out how far the connection between the NodeMCU and wifi is and at what distance wifi connection problems can cause this tool system to be unable to work. The Blynk application is tested by adjusting the distance between the NodeMCU and the internet connection (wifi). This test is carried out in an open space without obstacles between two objects at 1 meter to 12 meters which already proofed as distance which covers area of connection for the sensors (Syukhron, 2021). This test aims to find out how far the NodeMCU can reach the internet (wifi) to send data from measurement results.

Testing stages in the Blynk application:

1) Connect the wiring on the remote low-voltage power circuit breaker system in IoT monitoring-based flood areas.
2) The program created in the programming application is then input to the ESP8266 microcontroller.
3) Connect the tool to a 220 Volt AC voltage source.
4) Turn on the Hotspot on the smartphone or WiFi router that has been adjusted in the program. And make sure that Blynk receives data from NodeMCU
5) Determine the test distance from 1 meter until the Blynk application is disconnected.
6) If using WiFi internet access, bring and keep the NodeMCU according to the testing distance, and if using smartphone Hotspot internet access, bring and keep the smartphone according to the testing distance
7) Record the time delay received on Blynk at the test distance per meter.
8) Stop performing distance testing if Blynk connectivity is lost.

Based on tests that have been carried out to determine the connection distance between the NodeMCU ESP8266 microcontroller and an internet connection from either a WiFi router or smartphone hotspot, there is a time lag Blynk application can read how far the water level is. The following are the results of the data that have been tested and recorded in Table 3.

Test Results on the Blynk Application Based on tests that have been carried out to determine the connection distance between the NodeMCU ESP8266 microcontroller and an internet connection from either a WiFi router or smartphone hotspot, there is a time lag when the Blynk application can read how far the water level is. The following are the data results tested and recorded in Table 4. Analysis of Test Trip Results on the Blynk Application Manual MCCB test trip trials via the Blynk application has been carried out. The MCCB can be deactivated manually via the widget button on the Blynk smartphone application, which was previously programmed.

However, when the button is activated, there will be delayed in deactivating the MCCB because it takes time due to the signal, which could be better, causing delays. The average time for the widget button to deactivate the MCCB is around 2 seconds.

Table 3. Application Blynk with NodeMCU ESP 8266.

Distance (m)	Node MCU connection to ESP 8266	Declaration
1	Connected	-
2	Connected	-
3	Connected	-
4	Connected	1 second delayed
5	Connected	1 second delayed
6	Connected	1 second delayed
7	Connected	1 second delayed
8	Connected	1 second delayed
9	Connected	1 second delayed
10	Unconnected	-
11	Unconnected	-

Table 4. Trip MCCB testing.

Testing Number	Time to Trip MCCB (second)		
	MCCB1	MCCB2	MCCB3
1	2.16	3.03	3.12
2	1.20	1.34	1.27
3	1.76	1.33	1.33
4	2.11	2.40	2.25
5	2.26	2.54	2.40
Average Time	**1.89**	**2.12**	**2.07**

4. CONCLUSION

Based on the results of the design, testing, measurement, and analysis process of the system, each ultrasonic sensor has an error value and delayed connection time for Blynk application.

Both has maximal error below 0,5% and little more than 2 second delayed for connection time.

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